CLAIMS

What is claimed is:

1. A method of controlling a dispensing system **(14)** for dispensing a viscous material **(10)** onto a workpiece **(12)** at an actual dispensing rate within a minimum deviation of a target dispensing rate, said method comprising the steps of:

dispensing the viscous material **(10)** onto the workpiece **(12)** during a first time period **(T1)**;

measuring a pressure of the viscous material **(10)** after each of a plurality of time increments **(ti)** within the first time period **(T1)** as the viscous material **(10)** is dispensed during the first time period **(T1)**;

establishing an initial value **($f_{initial}$)** of a compensation factor **(f)**;

determining a theoretical volume of the viscous material **(10)** dispensed during the first time period **(T1)** based on the pressure measurements **(P)** during the first time period **(T1)** and the initial value **($f_{initial}$)** of the compensation factor **(f)**;

measuring an actual volume of the viscous material **(10)** dispensed during the first time period **(T1)**;

comparing the theoretical and actual volumes of the viscous material **(10)** dispensed during the first time period **(T1)**;

determining a first new value **(f_1)** for the compensation factor **(f)** based on the comparison between the theoretical and actual volumes of the viscous material **(10)** dispensed during the first time period **(T1)**;

dispensing the viscous material **(10)** onto the workpiece **(12)** during a second time period **(T2)**;

measuring a pressure of the viscous material **(10)** after each of a plurality of time increments **(ti)** within the second time period **(T2)** as the viscous material **(10)** is dispensed during the second time period **(T2)**;

determining a theoretical volume of the viscous material **(10)** dispensed during the second time period **(T2)** based on the pressure measurements **(P)** during the second time period **(T2)** and the first new value **(f_1)** for the compensation factor **(f)**;

measuring an actual volume of the viscous material **(10)** dispensed during the second time period **(T2)**;

comparing the theoretical and actual volumes of the viscous material **(10)** dispensed during the second time period **(T2)**; and

determining a second new value **(f_2)** for the compensation factor **(f)** based on the comparison between the theoretical and actual volumes of the viscous material **(10)** dispensed during the second time period **(T2)**;

said method characterized by at least a portion of the second time period **(T2)** occurring consecutively with the first time period **(T1)** to compensate the actual dispensing rate in the second time period **(T2)** for changes in operational characteristics of the viscous material **(10)** and the dispensing system **(14)** that occurred during the first time period **(T1)** thereby maintaining the actual dispensing rate within the minimum deviation of the target dispensing rate.

2. A method as set forth in claim 1 wherein measuring a pressure of the viscous material **(10)** after each of the plurality of time increments **(ti)** within the first **(T1)** and second **(T2)** time periods further comprises receiving a control signal **(40)** from a pressure sensor **(36)** after each of the plurality of time increments **(ti)** in the first **(T1)** and second **(T2)** time periods and converting the control signals **(40)** into the pressure measurements **(P)**.

3. A method as set forth in claim 2 wherein the steps of measuring the actual volume of the viscous material **(10)** dispensed over the first **(T1)** and second **(T2)** time periods further comprises receiving first **(34a)** and second **(34b)** electrical pulses generated by a flow meter **(32)** of the dispensing system **(14)** whereby the first pulse **(34a)** indicates that a preset volume of the viscous material **(10)** has passed through the flow meter **(32)** during the first time period **(T1)** and the second pulse **(34b)** indicates that the preset volume of the viscous material **(10)** has passed through the flow meter **(32)** during the second time period **(T2)**.

4. A method as set forth in claim 3 further comprising determining a theoretical dispensing rate after each pressure measurement **(P)** is taken.

5. A method as set forth in claim 4 further comprising comparing the

theoretical dispensing rate to the target dispensing rate and adjusting a voltage applied to a variable orifice servo valve **(44)** of a pressure regulator **(42)** based on a difference between the theoretical dispensing rate and the target dispensing rate.

6. A method as set forth in claim 5 further comprising determining a theoretical accumulated volume of the viscous material **(10)** dispensed over the **(T1)** and second **(T2)** time periods and determining a target accumulated volume of the viscous material **(10)** dispensed over the first **(T1)** and second **(T2)** time periods.

7. A method as set forth in claim 6 further comprising comparing the theoretical accumulated volume with the target accumulated volume and adjusting the voltage applied to the variable orifice servo valve **(44)** based on a difference between the theoretical accumulated volume and the target accumulated volume.

8. A method as set forth in claim 1 further comprising establishing a cracking pressure **(b)** of the dispensing system **(14)** whereby the cracking pressure **(b)** represents frictional losses in the dispensing system **(14)** to be overcome by the viscous material **(10)** in order to begin dispensing onto the workpiece **(12)**.

9. A method as set forth in claim 8 further comprising establishing a linearity factor **(N)** for the viscous material **(10)** whereby the linearity factor **(N)** represents shear thinning or shear thickening properties of the viscous material **(10)**.

10. A method as set forth in claim 9 wherein the steps of determining the theoretical volume of the viscous material **(10)** dispensed over each of the first **(T1)** and second **(T2)** time periods are further defined as determining the theoretical volume using the equation,

$$\text{theoretical volume} = \Sigma_T \, [(P_{ti} - b) / f]^N$$

wherein f is the compensation factor, b is the cracking pressure, P_{ti} is the pressure measurement taken at each time increment **(ti)**, T is the time period, and N is the

linearity factor.

11. A method as set forth in claim 10 wherein comparing the theoretical volume with the actual volume is further defined as equating the theoretical volume to the actual volume in the equation,

$$\text{actual volume} = \text{theoretical volume} = \Sigma_T\,[(P_{ti} - b) / f]^N$$

wherein f is the compensation factor, b is the cracking pressure, P_{ti} is the pressure measurement taken at each time increment **(ti)**, T is the time period, and N is the linearity factor.

12. A method as set forth in claim 11 wherein determining the theoretical dispensing rate after each pressure measurement **(P)** is taken further includes determining the theoretical dispensing rate using the equation,

$$\text{theoretical dispensing rate} = [(P - b) / f]^N$$

wherein f is the compensation factor, b is the cracking pressure, P is the pressure measurement, and N is the linearity factor.

13. A method as set forth in claim 1 further including detecting an obstruction in the dispensing system **(14)** based on the difference between the first **(f_1)** and second **(f_2)** new values for the compensation factor **(f)**.

14. A method as set forth in claim 1 further including detecting air bubbles within the dispensing system **(14)** based on the difference between the first **(f_1)** and second **(f_2)** new values for the compensation factor **(f)**.

15. A method as set forth in claim 1 further including detecting wear of a nozzle **(26)** of the dispensing system **(14)** based on either of the first **(f_1)** and second **(f_2)** new values for the compensation factor **(f)**.

16. A method as set forth in claim 1 wherein the second time period **(T2)** in entirety occurs consecutively with the first time period **(T1)** to compensate the actual dispensing rate in the second time period **(T2)** for changes in the operational characteristics of the viscous material **(10)** and the dispensing system **(14)** that occurred during the first time period **(T1)** thereby maintaining the actual dispensing rate within the minimum deviation of the target dispensing rate during the second time period **(T2)**.

17. A method as set forth in claim 1 wherein a portion of the second time period **(T2)** overlaps the first time period **(T1)** to compensate the actual dispensing rate in the second time period **(T2)** for changes in the operational characteristics of the viscous material **(10)** and the dispensing system **(14)** that occurred during the first time period **(T1)** thereby maintaining the actual dispensing rate within the minimum deviation of the target dispensing rate.

18. A method as set forth in claim 1 wherein the steps of dispensing the viscous material **(10)** onto the workpiece **(12)** during each of the first **(T1)** and second **(T2)** time periods are further defined as dispensing the viscous material **(10)** at a viscosity of between 5 and 60,000 mPa · s onto the workpiece **(12)** during each of the first **(T1)** and second **(T2)** time periods.

19. A dispensing system **(14)** for dispensing a viscous material **(10)** onto a workpiece **(12)** at an actual dispensing rate within a minimum deviation of a target dispensing rate, said system comprising:

a delivery conduit **(20)**;

a flow meter **(32)** coupled to said delivery conduit **(20)** for measuring an actual volume of the viscous material **(10)** dispensed onto the workpiece **(12)** during a first time period **(T1)**;

a nozzle **(26)** coupled to said delivery conduit **(20)** for directing the viscous material **(10)** onto the workpiece **(12)**;

a robot **(28)** having a robot arm **(30)** for controlling a position of said nozzle **(26)** relative to the workpiece **(12)**;

a pressure sensor **(36)** positioned within said nozzle **(26)** for measuring a pressure of the viscous material **(10)** as the viscous material **(10)** is dispensed onto the workpiece **(12)** during the first time period **(T1)**;

a pressure regulator **(42)** coupled to said delivery conduit **(20)** for controlling the actual dispensing rate that the viscous material **(10)** is dispensed through said nozzle **(26)**; and

a controller **(48)** operatively connected to said flow meter **(32)**, said pressure sensor **(36)**, and said pressure regulator **(42)** and programmed for determining a theoretical volume of the viscous material **(10)** dispensed onto the workpiece **(12)** during the first time period **(T1)** based on the pressure measurements **(P)** and comparing the theoretical volume to the actual volume to derive a first new value **(f_1)** for a compensation factor **(f)** and control the pressure regulator **(42)** accordingly.

20. A system as set forth claim 19 further including a pump **(18)** coupled to said delivery conduit **(20)** for conveying the viscous material **(10)** through said delivery conduit **(20)** to said nozzle **(26)**.

21. A system as set forth in claim 20 wherein said pressure regulator **(42)** includes a variable orifice servo valve **(44)** and said controller **(48)** being programmed for regulating said variable orifice servo valve **(44)** based on the difference between the theoretical volume and the actual volume of the viscous material **(10)** dispensed during

the first time period **(T1)**.

22. A system as set forth in claim 21 wherein said robot **(28)** defines six rotational axes **(A1-A6)** for rotating thereabout.

23. A system as set forth in claim 19 wherein said nozzle **(26)** is disposed on said robot arm (30).

24. A system as set forth in claim 19 wherein said robot **(28)** is a dispensing robot.

25. A method of controlling a dispensing system **(14)** for dispensing a viscous material **(10)** onto a workpiece **(12)** at an actual dispensing rate within a minimum deviation of a target dispensing rate, said method comprising the steps of:

receiving control signals **(40)** from a pressure sensor **(36)** after each of a plurality of time increments **(ti)** within a first time period **(T1)** as the viscous material **(10)** is dispensed during the first time period **(T1)**;

receiving a first pulse **(34a)** from a flow meter **(32)** after receiving the control signals **(40)** from the pressure sensor **(36)** within the first time period **(T1)**;

determining a theoretical volume of the viscous material **(10)** dispensed during the first time period **(T1)** based on the control signals **(40)** received during the first time period **(T1)** and an initial value **($f_{initial}$)** of a compensation factor **(f)**;

determining an actual volume of the viscous material **(10)** dispensed during the first time period **(T1)** based on the first pulse **(34a)**;

comparing the theoretical and actual volumes of the viscous material **(10)** dispensed during the first time period **(T1)**;

determining a first new value **(f_1)** for the compensation factor **(f)** based on the comparison between the theoretical and actual volumes of the viscous material **(10)** dispensed during the first time period **(T1)**;

receiving control signals **(40)** from the pressure sensor **(36)** after each of a plurality of time increments **(ti)** within a second time period **(T2)** as the viscous material **(10)** is dispensed during the second time period **(T2)**;

receiving a second pulse **(34b)** from the flow meter **(32)** after receiving the control signals **(40)** from the pressure sensor **(36)** within the second time period **(T2)**;

determining a theoretical volume of the viscous material **(10)** dispensed during the second time period **(T2)** based on the control signals **(40)** received during the second time period **(T2)** and the first new value **(f_1)** for the compensation factor **(f)**;

determining an actual volume of the viscous material **(10)** dispensed during the second time period **(T2)** based on the second pulse **(34b)**;

comparing the theoretical and actual volumes of the viscous material **(10)** dispensed during the second time period **(T2)**; and

determining a second new value **(f_2)** for the compensation factor **(f)** based on the comparison between the theoretical and actual volumes of the viscous material **(10)**

dispensed during the second time period **(T2)**;

said method characterized by the second pulse **(34b)** occurring consecutively with the first pulse **(34a)** to compensate the actual dispensing rate in the second time period **(T2)** for changes in operational characteristics of the viscous material **(10)** and the dispensing system **(14)** that occurred during the first time period **(T1)** thereby maintaining the actual dispensing rate within the minimum deviation of the target dispensing rate.